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ABSTRACT

When the Trust Territory of the Pacific Islands gradually dissolved in the 1980s, the Republic of Palau assumed a greater responsibility for its own education system. In order to monitor the mathematical achievement of elementary school students during the transition from external to local control of educational procedures, basic skills mathematics tests were administered to students in two elementary schools in Palau. This official report to the Ministry of Education in Palau, which was prepared by a University of Hawaii researcher, describes the various testing activities undertaken from 1984 to 1990, summarizes the results of those testing activities, and makes recommendations for continuation of this study. (Author)

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A Report to the Ministry of Education on the Status of Mathematics Achievement in Two Elementary Schools in Palau 1984-1990

submitted by

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Abstract

When the Trust Territory of the Pacific Islands gradually dissolved in the 1980s, the Republic of Palau assumed a greater responsibility for its own education system. To monitor the mathematical achievement of students during the transition from external to local control of education, basic skills mathematics tests were administered to students in two elementary schools in Palau. This paper - an official report to the Ministry of Education in Palau prepared by a University of Hawaii researcher - describes the various testing activities undertaken from 1984 to 1990, summarizes the results of the testing, and makes recommendations for continuing the study.

Introduction for ERIC Readers

Palau is a nation of about 200 islands located in the western Pacific Ocean south of Guam, east of the Philippine Islands, and north of New Guinea. For the last 450 years Palau has been ruled by foreign nations, including Spain (1543-1898), Germany (1898-1914), Japan (1914-1947), and the Trust Territory of the Pacific Islands under the administration of the United States (1947 to the present). After being governed for more than 30 years by the United States, the districts of Micronesia which comprised the Trust Territory sought political independence. Saipan became a commonwealth; Yap, Truk, and Ponape joined together to form the Federated States of Micronesia; and the Marshall Islands became a nation. Only Palau has failed to negotiate a settlement with the United States; in seven plebiscites the people of Palau have failed to ratify a treaty. Negotiations are still underway, but in the meantime Palau became responsible for its own educational system for the first time in its history. The studies reported below are part of an ongoing project to monitor the mathematics achievement of students in Palau during the transition to independence and local control.

The project began in 1982 when Basilio Deltang, the Mathematics Specialist for the Republic of Palau, asked me if I thought it were possible to improve the math achievement level of students in Palau. A small amount of money was available for beginning a mathematics project, and we undertook this project with the expectation that more funds would be available as soon as the Republic of Palau had negotiated a formal treaty with the United States. Unfortunately, a treaty with the United States has never been ratified, and the political status of Palau remains in limbo to this day. In the meantime, we have struggled to maintain an on-going mathematics project during these years. The purpose of this report is to describe the activities of the project and to summarize the results.

The Preparation Phase: 1983-1984

Scope and Sequence Chart

There is no kindergarten in Palau, and children enter school with little proficiency in English. Yet American textbooks are used in Palauan schools. After analyzing the mathematics textbooks being used in Palauan schools, I concluded there was a mismatch between the topics in the textbooks and the cognitive readiness of the students: many of the goals expected of

students were unrealistic and unachievable. Therefore, I developed a scope and sequence chart which would realistically reflect the needs of Palauan students.

Seven principles guided the development of the scope and sequence chart, and these resulted in the following changes;

1) Many topics were placed later in the school curriculum. For example, problems dealing with dimes, quarters, and nickels were moved from the first grade to the third grade.

2) Some topics were eliminated Topics dealing with set theory and the field properties (associative, distributive, and commutative properties) were not included in the chart

3) An emphasis was placed on the learning of basic skills. Computation was presented at a slower pace than in American textbooks, and each step in each algorithm was more carefully and thoroughly developed.

4) Computational problems was presented with a gradual increase in difficulty. No steps were left to chance.

5) More provision was provided for drill and practice to ensure learning. By eliminating esoteric topics, more time was allowed for mastery learning.

6) "Problem solving" was interpreted to mean the solution of real world word problems and not the solution of "unique" problems.

7) The use of hand-held calculators was limited until students had an opportunity to master the basic skills.

Using these seven principles as guides, I developed a scope and sequence chart for Palau. It has never been formally adopted, but it has guided the activities of this project. For example, the decision not to test first graders on addition and subtraction, even though these topics appear in the standard textbooks, was a direct outcome of the scope and sequence chart.

Computer Generated Arithmetic Programs

The presentation of basic skills in elementary school textbooks often combine several skills in one lesson without adequate skill preparation. For example, a simple multiplication problem, such as 57x74, requires a knowledge of the multiplication facts, the ability to carry and add a 1-digit number to a 2-digit number in one's head, the ability to add two columns of numbers, and the ability to carry in addition. If these skills have to be learned at the same time the student is

learning the steps in the basic algorithm, cognitive overload may result in the minds of some children.

Therefore, I saw a need to develop a sequence of arithmetic problems which adequately prepared the students for each and every step in the development of the computational skills in the elementary school curriculum. To do so, I wrote a series of 178 computer programs which would randomly generate arithmetic problems of very specific types. These programs are designed to be sequential and to introduce only one new step in an algorithmic procedure at a time. It is my belief that this type of gradual development will best insure success for the learner.

Supplemental Arithmetic Booklets

Using the computer program to generate arithmetic problems, I then wrote four supplementary booklets, one each on addition, subtraction, multiplication, and division. It was intended that these booklets be used as a supplement to the regular textbook to see if they would be successful in improving achievement scores in Palau.

Test Instrument

Since the purpose of the project was to see if math achievement scores could be improved, I developed a test

for each grade level in the elementary school. Parallel forms of the test have been used throughout the six years of the project. This section describes how the tests were developed and administered.

Selection of Skills to be Measured

Standard American textbooks are used in Palau. Children entering school do not typically speak or understand English well, and so teachers translate and interpret much of the mathematics from the English textbook into the Palauan language. Since computational skills are fairly independent of language and are relatively culturally unbiased, a decision was made to limit the testing to computational skills. This is also consistent with the belief that computational skills and number familiarity form the backbone of mathematical literacy in the elementary grades.

Test Construction

The Micronesian Achievement Test is a multiple-choice test normed on students in Micronesia, and it was available for this study. However, it was not used because: 1) it had a multiple-choice format; 2) it did not adequately test for the immediate recall of mathematical facts and computational skills; 3) it contained items which were dependent upon an

understanding of the English language; and 4) it was costly to score the tests.

A set of criterion referenced tests, which I wrote, were used instead. The tests were written to reflect the actual content taught at each grade level in Palau. There is no kindergarten in Palau, and first graders typically cover math readiness concepts from the kindergarten curriculum. Additionally, since English is a second language for the students, it is generally the case that each grade level in Palau is about one year behind the sequencing in American textbooks. Addition is the focus of instruction in the second grade, subtraction in the third, multiplication in the fourth, and division in the fifth. Therefore, a decision was made to concentrate the testing on the four basic operations of arithmetic at grades two, three, four, and five. In 1987 the sixth graders were also tested, and so computation with fractions, computation with decimals, and word problems (problem solving) were added to the battery of tests.

Two types of tests were constructed. The first was a timed test on basic facts. There were four tests in all, one for each of the basic operations of arithmetic. The tests contained 30 items and had a one-minute time

limit. The second type of test was on computational skills using standard algorithms. Again there were four tests, one for each of the basic operations, each of which contained six problems of increasing difficulty. A time limit of two minutes was given for each computational test.

As mentioned above, three additional areas were added to the testing in 1987. In an attempt to measure problem solving skills, four word problems were included. The first required one operation; the second required two operations; the third three; and the fourth four. The second area added was computation with common fractions. The test included two items for each of the four basic operations. The same structure was followed for decimals. Hence, the testing included four word problems to measure problem solving skills, eight fraction problems, and eight decimal problems. Two minutes were allowed for each word problem; two minutes were allowed for the fractions; and two minutes were allowed for the decimals.

The Testing Procedure

The same testing procedure was used in both the longitudinal and the experimental studies which I shall describe below. The Mathematics Specialist and his

staff assisted in administering the tests. Precise testing protocols were established and a briefing for the test administrators was given prior to each year's testing. The tests were administered in individual classrooms with the directions for each section of the test read aloud in both English and Palauan. The time required to administer the tests ranged from less than ten minutes for the second grade to more than thirty minutes for the sixth grade to more than several hours for each first grade classroom (the students in the latter being tested individually).

Harris School: 1984-1985

Methods

In 1984 the supplementary booklets were tested at Harris Elementary School. The ideas was to have the teachers use the booklets to supplement their regular mathematics textbooks in a effort to improve math achievement scores.

Since there is no kindergarten in Palau, and since first graders speak English with limited proficiency, a decision was made to test the addition booklets with second graders, the subtraction booklets with third graders, the multiplication booklets with fourth graders, and the division booklets with the fifth

graders. Even though there were no supplementary learning materials for the first graders, we decided to test them to see how well they learned to count, read, and write numbers during that year.

In September of that year I took a sabbatical leave from the University of Hawaii to initiate the pilot study at Harris Elementary School. I prepared an outline for each teacher which indicated how the supplementary booklets might be integrated into the regular curriculum, and I conducted a training session with the teachers at each grade level. Then, with the assistance of the Mathematics Section in Palau, a pretest was administered to all students in grades 2-5 at Harris Elementary School. The teachers in grades 2-5 at Harris were asked to use the supplementary math booklets throughout the year. In May of 1985 a posttest was administered to the students.

Results

Appendix A contains a list of tables and Appendix B contains a list of figures which help explain the results. Table A-1 (see Appendix A) shows the results of the testing. There was a gain on every skill at every grade level. The largest gain was 60% on second grade addition, and the highest posttest score was 98%

on fifth grade addition computation. These are excellent results. However, some of the other scores are less than we would like.

Discussion

The tests were constructed as criterion referenced tests. It was hoped that the more competent and motivated students would score 100% on the tests. Some students did so. As a whole, we would be satisfied with average scores in the 80s or higher. This should remain our goal.

After talking with some of the teachers, I realized that the strategy for the use of the supplementary booklets could have been better. For example, only the addition booklet was used at the second grade level, and the booklet included the very simple to the very complicated problems. The more difficult problems were too difficult for second graders. Similarly, the fourth graders used only the multiplication booklets. They might have profited from a carefully sequenced set of

addition and subtraction problems as well. Such considerations led to the next phase of the project.

Experimental Study: 1986-1987

Nothing was done on the project during the 1985-1986 school year. In 1986 the project continued in a slightly different direction: a pretest/posttest control group design was used to test the effectiveness of a new set of mathematics booklets.

Mathematics Booklets

Instead of just using the computation booklets, I decided to create a series of twenty-six booklets which spanned grades 1-6. In addition to computational skills, these booklets contained a wide range of skills and concepts taken from the previously developed scope and sequence chart.

Methods

The experiment was designed to see if students using a supplemental program would outperform students using the regular math textbooks on a test of basic mathematical skills. One teacher at each of the grades from two through six were chosen as the Experimental Teachers. The other teachers at Harris and the teachers at Meyuns served as the Control Teachers. Using the tests and procedures described above, the students were tested in September of 1986 and May of 1987.

The Experimental Group teachers were asked to use a series of twenty-six supplementary booklets especially designed for the experiment and the Control Group used the regular math textbooks The supplemental booklets were labeled from A to Z, and each grade level used five or six booklets during the year. The major characteristic of the booklets was the gradual and careful introduction of computational skills to the students. Each lesson built upon the preceding one with no more than one new skill required at each level. This approach keeps the instruction simple and provides more practice than with traditional approaches to the subject.

Results

The analysis was performed on the gain scores from pretest to posttest. The results are presented from three different perspectives: 1) by grade level; 2) by mathematical skills; and 3) by the total performance in each group.

Grade Level

The Experimental classes outperformed the Control classes at each grade level. The graph in Figure B-1 (see Appendix B) shows the results in terms of gain scores. At the second grade level the Experimental

Group gained 56% and the Control Group gained 38%; at the third grade it was 37% to 26%; at the fourth grade it was 43% to 29%; at the fifth grade it was 37% to 28%; and at the sixth grade the Experimental Group gained 40% and the Control Group 18%.

An Analysis of Variance (ANOVA) was run on each grade level. Using a p-value of 0.05, the results were statistically significant at the third, fourth, and sixth grade levels, but not at the second and fifth grade levels. Table A-2 contains the ANOVA summaries for grade levels.

Math Skills

When the data was analyzed along the skills axis, the Experimental Group also outperformed the Control Group on every skill. Figure B-2 shows the average gain score for both groups. For example, in the Experimental Group the average student had a pretest-to-posttest gain of 36% on the addition problems. This includes students at all the grade levels.

The Experimental Group outperformed the Control Group on each of the other skill areas: 33% to 18% for subtraction; 53% to 37% for multiplication; 46% to 36% for division; 71% to 28% for fractions; 28% to 16% for decimals; and 23% to 11% on word problems.

Table A-3 contains the ANOVA results for the math skills. Using a p-value of 0.05, the differences were statistically significant for addition, subtraction, multiplication, fractions, and problem solving. The results were not significant for division and decimals.

Total Group Performance

The final analysis involved forming a total score by adding all the individual gain scores, then computing a group average. The average overall gain score in the Experimental Group was 66.2, while the average overall gain score was 29.7 in the Control Group.

Discussion

The results show that the students using the supplemental math booklets outperformed the Control Group on every skill and at each grade level, although not all of the differences were statistically significant. However, there were several factors which may have contaminated the intent of the experiment. After the year was over, I discovered that a new mathematics textbook series had been introduced into the schools in Palau that year, and an end-of-the-year test was administered to measure objectives from that textbook series. As a result some of the Experimental teachers may not have used the supplementary materials

as faithfully as they might have. I have this feeling because, while administering the posttest, I saw copies of the Experimental booklets which had not been fully used. If some of the Experimental teachers did not use the materials as intended, the true impact of the supplementary materials is in doubt.

Nonetheless, the fact that the Experimental Group outperformed the Control Group on every measure suggests to me that scores can be increased if teachers focus on the student achievement.

The Longitudinal Studies: 1984-1990

Nothing more was done with the project until May of 1990. Data from Harris School was available from September 1984, May 1985, September 1986, and May 1987. Data from Meyuns School was available from September 1986 and May 1987. If we tested the students again in May 1990, we would have a longitudinal look at math achievement over a five-year period of time.

Hence, in May of 1990 the test was administered in these two schools once again, with one notable change in procedure. The first graders had to be tested individually, and this takes about fifteen minutes per student. Hence, it takes more time to test the first graders than it does to test all of the other grades

combined. Since I was relying upon the voluntary efforts of others to collect the data, I decided not to test the first graders in 1990.

The basic purpose of the longitudinal study is to see how well achievement scores are doing at Harris and Meyuns schools over the long run. In other words, are achievement scores increasing, decreasing, or remaining the same in these schools? To examine this question in more detail, data was collected to answer the following three questions: 1) Did achievement scores increase on each skill at each grade level? For example, did scores on addition facts for third graders increase?; 2) Did achievement scores increase on each skill for the entire school (all grade levels combined)? For example, did scores on subtraction increase when all grade levels were combined?; 3) Did the total achievement score (all skills combined) increase at each grade level over the years?

End-of-Year Testing at Harris School: 1985-1990

This section summarizes the data at Harris School from May 1985, May 1987, and May 1990.

Question 1: Did achievement scores increase on each skill at each grade level? Table A-4 summarizes

the data. A downward trend in achievement is very evident: skills decreased on 26 of the 33 tests. The largest decline was 42% on second grade addition facts. The largest gain was 25% on third grade subtraction facts.

Question 2: Did achievement scores increase on each skill for the entire school (all grade levels combined)? Figure B-3 summarizes the overall results on basic skills taken across all grade levels at Harris School. The graph shows that the average score on each skill decreased from 1985 to 1990.

Question 3: Did the total achievement score (all skills combined) increase at each grade level? Figure B-4 shows that when all skills are combined together for a total test scores, there was an decrease in achievement at all grades except the third grade.

- The results are clear: achievement scores on basic math skills have declined steadily at Harris School from 1985 to 1990.

Beginning-of-Year Testing at Harris School: 1984-1986

Data was also collected at Harris School in the beginning of two school years, in September of 1984 and in September of 1986. Table A-5 summarizes the data for these years. Of the 20 tests administered, there was a

decrease on 14 of them and an increase on 6 tests. This suggests that students entering Harris School in 1986 were less prepared in math skills than students entering the same school in 1984. This is consistent with the downward trend in scores which were detected on the tests administered at the end of the year.

End-of-Year Testing at Meyuns School: 1987-1990

This section reports the results of the testing at Meyuns School from May 1987 and May 1990.

Question 1: Did achievement scores increase on each skill at each grade level? Table A-6 summarizes the results for Meyuns School. Achievement increased on 25 grade level tests and decreased on only 5 tests.

Question 2: Did achievement scores increase on each skill for the entire school (all grade levels combined)? Figure B-5 summarizes the results of the data when analyzed by skill areas. When each skill is combined across grade levels, there was an increase on every skill from 1987 to 1990.

Question 3: Did the total achievement score increase at each grade level? Figure B-6 summarizes the results of the data when analyzed by grade level. When all items are combined for a given grade level, the

results show an overall increase in student achievement at each grade level in Meyuns School.

Therefore, the scores at Meyuns School increased at every grade level and on every skill.

Discussion of the longitudinal Studies

The data show a steady decline in mean scores in Harris School and a steady increase in mean scores in Meyuns School. These trends suggested a comparison of the two schools In 1987 Harris outperformed Meyuns at every grade level (see Figure B-7). However, in 1990 Meyuns outperforms Harris at each grade level (see Figure B-8).

The results show a downward trend in one school, an upward trend in the other. While this is cause for concern, this does not necessarily mean that the students and teachers in one school are doing a good job and the teachers and students in the other school are doing a poor job. There are many factors which might account for these trends. Let me list a few of the factors which might be involved:

1) In testing, there is a phenomenon called "regression towards the mean". This means that an individual who scores high on one test has the tendency to score lower on the next; and an individual who

scores low on a test will tend to score higher on the next. Since Meyuns scored lower initially, this might account for some of the comparative changes in the scores at Harris and Meyuns.

2) Meyuns has fewer teachers and students than Harris. It is easier to change a small school than a large school. This might be a factor in the increase in scores at Meyuns.

3) The demographics of the student populations in each school might have changed over the past few years. Are there more immigrants in one school than the other? Are there any other differences in the student populations? And so on.

4) Is there a difference in school policy regarding homework? Or memorizing basic facts? Or classroom instruction? Are the teachers in each school equally concerned with how well students learn the basic skills?

5) Is there a difference in the amount of parental support in each school? Is there an active parent of community group involved with the school?

6) Is there a difference in the amount and kind of teaching materials? Books, workbooks, drill and practice materials, and so on?

7) Is there aggressive leadership in the school? Does the principal check on each teacher on a regular basis? Is the principal highly visible as the leader in the school? The school principal can make a difference.

8) Has there been a turn-over in the teaching staff in either school? Is the morale of the teachers high? Or is there any friction between teachers? Or between teachers and the principal?

9) Are there any subtle social differences between the neighborhoods of the two schools which might account for the changes? Does one have television and the other not? Is there an after-school program in one and not the other? Is there a strong religious influence in one and not the other? And so on.

These are a few of the things which might be considered in trying to understand what the results of this study really mean. This data should be presented to the principals and teachers in each school without value judgments being attached to it. Each school faculty should try to analyze their own situations to see if they can make sense of the data. Hopefully the factors contributing to the downward trend can be identified and corrected, and hopefully the factors contributing to the upward trend can be continued.

Looking to the Future

The testing at Harris and Meyuns Schools has provided useful information on the achievement patterns of students in Palau. The fact that achievement in one school is increasing is indeed encouraging. I am also encouraged by the results of the comparative study. It shows that students using an approach which stressed basic skills did in fact produce higher achievement than the regular textbook. Should funds become available in the future, this might be a fruitful avenue to pursue.

On the other hand, it is feasible to continue the end-of-the-year testing program, for it can be accomplished with very little money. If the program is formally announced, I think it will encourage the faculties of each school to focus more intently upon student achievement.

If the Ministry of Education is willing to cooperate in the administration of tests at Harris and Meyuns schools, I am willing to analyze of the data and file a written report each year as part of my long-range university research agenda. The cost would be minimal, and the testing could be a part of the total evaluation effort by the Ministry of Education.

Appendix A. Tables

Table A-1

Gain Scores at Harris School 1984-1985

	Pre	Post	Gain
Second Grade			
Addition facts	23%	76%	53%
Addition computation	19%	79%	60%
Third Grade			
Addition facts	37%	49%	12%
Addition computation	41%	82%	41%
Subtraction facts	18%	27%	9%
Subtraction computation	16%	56%	40%
Fourth Grade			
Addition facts	56%	85%	29%
Addition computation	67%	93%	26%
Subtraction facts	38%	61%	23%
Subtraction computation	47%	86%	39%
Multiplication facts	33%	64%	31%
Multiplication computation	17%	48%	31%
Fifth Grade			
Addition facts	70%	89%	19%
Addition computation	70%	98%	28%
Subtraction facts	48%	64%	16%
Subtraction computation	50%	77%	27%
Multiplication facts	44%	89%	45%
Multiplication computation	22%	54%	32%
Division facts	27%	74%	47%
Division computation	15%	36%	21%

Table A-2

Grade Level Differences at Harris & Meyuns

Grade 2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F-RATIO	PR>F
Between	1	471.37	471.37	3.82	0.0558
Within	53	6532.74	123.26		

Grade 3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	1590.17	1590.17	7.68	0.007
Within	71	14707.75	207.15		

Grade 4

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	6815.42	6815.42	21.22	148E-7
Within	82	26330.72	321.11		

Grade 5

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	1883.80	1883.89	2.87	0.0937
Within	89	58412.88	656.32		

Grade 6

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	21243.06	21243.06	31.70	171E-7
Within	98	65663.69	670.04		

Table A-3

Skill Differences at Harris & Meyuns

Addition

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	3235.80	3235.80	45.17	62E-12
Within	401	28725.66	71.64		

Subtraction

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	1724.35	1724.35	25.95	578E-9
Within	346	22994.65	66.46		

Multiplication

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	1429.12	1429.12	19.43	150E-7
Within	273	20081.48	73.56		

Division

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	461.01	461.01	3.34	0.0691
Within	189	26067.97	137.93		

Fractions

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	190.44	190.44	42.69	29E-10
Within	98	437.2	4.46		

Decimals

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	14.44	14.44	3.74	0.0561
Within	98	378.55	3.86		

Problem Solving

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO	PR>F
Between	1	6.40	6.40	4.97	0.0269
Within	189	243.28	1.29		

Table A-4

End-of-Year Longitudinal Data at Harris School

	1985	1987	1990	Total Gain
Second Grade				
Add. facts (30)	74%	70%	37%	-37%
Add. Computation (6)	57%	46%	52%	- 5%
Third Grade				
Add. facts (30)	61%	71%	76%	+15%
Add. Computation (6)	63%	59%	67%	+ 5%
Subt. facts (30)	38%	42%	64%	+26%
Subt. computation (6)	55%	36%	52%	- 3%
Fourth Grade				
Add. facts (30)	90%	78%	68%	-22%
Add. Computation (6)	83%	78%	79%	- 4%
Subt. facts (30)	74%	48%	50%	-24%
Subt. computation (6)	82%	63%	58%	-24%
Mult. facts (30)	75%	66%	52%	-23%
Mult. computation (6)	61%	41%	- - -	-20%
Fifth Grade				
Add. facts (30)	81%	90%	84%	+ 3%
Add. Computation (6)	83%	80%	75%	- 8%
Subt. facts (30)	84%	74%	75%	- 9%
Subt. computation (6)	80%	82%	71%	- 9%
Mult. facts (30)	80%	81%	84%	+ 4%
Mult. computation (6)	58%	51%	60%	+ 2%
Div. facts (30)	89%	71%	69%	-20%
Div. computation (6)	48%	28%	27%	-21%
Word Problems (4)	no data	09%	14%	+ 5%
Sixth Grade				
Add. facts (30)	not given	96%	92%	- 4%
Add. Computation (6)	not given	90%	83%	- 7%
Subt. facts (30)	not given	90%	83%	- 7%
Subt. computation (6)	not given	89%	75%	-14%
Mult. facts (30)	not given	94%	87%	- 7%
Mult. computation (6)	not given	76%	66%	-10%
Div. facts (30)	not given	94%	90%	- 4%
Div..computation (6)	not given	49%	40%	- 9%
Word Problems (4)	not given	31%	25%	- 6%
Fractions (8)	not given	65%	50%	-15%
Decimals (8)	not given	66%	46%	-20%

Table A-5

Beginning-of-Year Longitudinal Data at Harris School

	1984	1986	Total Gain
Second Grade			
Addition facts	23%	16%	-7%
Addition computation	19%	1%	-18%
Third Grade			
Addition facts	37%	35%	-2%
Addition computation	41%	24%	-17%
Subtraction facts	18%	54%	+36%
Subtraction computation	16%	12%	-2%
Fourth Grade			
Addition facts	56%	62%	+6%
Addition computation	67%	44%	-23%
Subtraction facts	38%	33%	-5%
Subtraction computation	47%	34%	-13%
Multiplication facts	33%	6%	-27%
Multiplication computation	17%	2%	-15%
Fifth Grade			
Addition facts	70%	75%	+5
Addition computation	70%	51%	-19%
Subtraction facts	48%	53%	+5%
Subtraction computation	50%	44%	-6%
Multiplication facts	44%	34%	-10%
Multiplication computation	22%	28%	+6%
Division facts	27%	29%	+2%
Division computation	15%	4%	-11%

Table A-6

Longitudinal Data at Meyuns School

	1987	1990	Total Gain
Second Grade			
Addition facts	42%	42%	0%
Addition computation	33%	58%	+25%
Third Grade			
Addition facts	50%	78%	+28%
Addition computation	55%	63%	+8%
Subtraction facts	30%	69%	39%
Subtraction computation	31%	35%	+4%
Fourth Grade			
Addition facts	69%	98%	+29%
Addition computation	75%	83%	+8%
Subtraction facts	56%	82%	26%
Subtraction computation	67%	64%	-3%
Multiplication facts	56%	66%	+10%
Multiplication computation	36%	no data	no data
Fifth Grade			
Addition facts	90%	97%	+7%
Addition computation	81%	85%	+4%
Subtraction facts	70%	87%	+17%
Subtraction computation	71%	66%	-5%
Multiplication facts	82%	88%	+6%
Multiplication computation	48%	38%	-10%
Division facts	78%	81%	+3%
Division computation	14%	25%	+11%
Word Problems	6%	3%	-3%
Sixth Grade			
Addition facts	73%	97%	+24%
Addition computation	84%	89%	+5%
Subtraction facts	69%	90%	+21%
Subtraction computation	74%	81%	+7%
Multiplication facts	72%	90%	+18%
Multiplication computation	52%	55%	+3%
Division facts	76%	86%	+10%
Division computation	22%	24%	+2%
Word problems	5%	22%	+17%
Fractions	4%	40%	+36%
Decimals	39%	35%	-4%

Appendix B. Figures

Figure B-1. Experimental and Control Group grade level comparisons

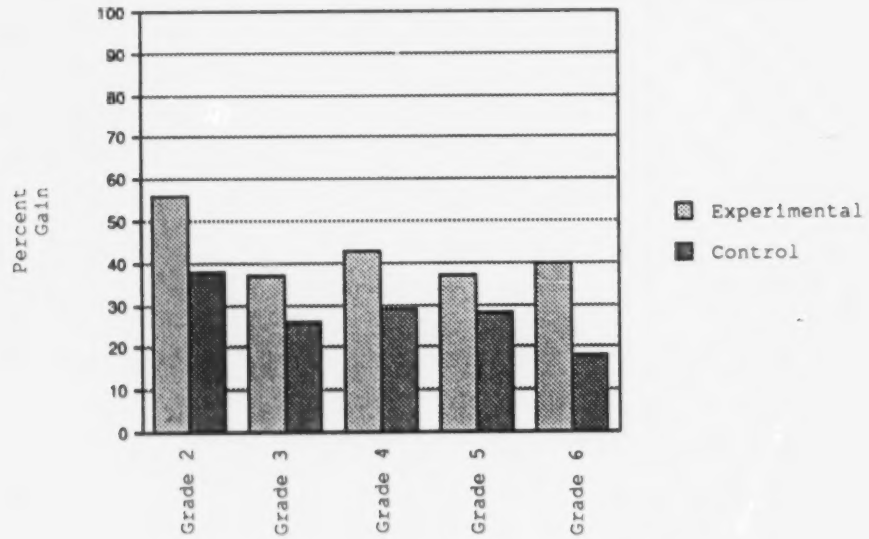

Figure B-2. Experimental & Control Group Comparisons on Skills

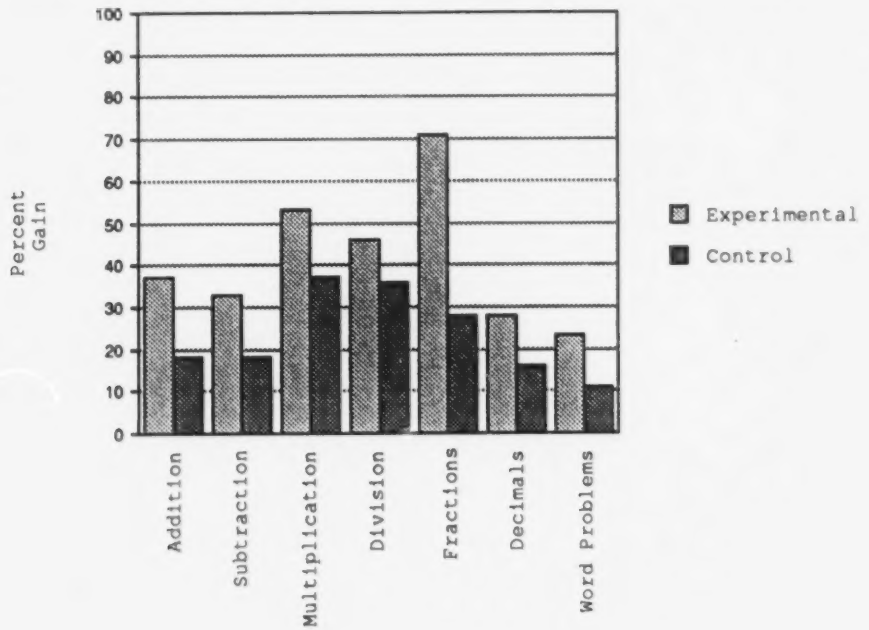

Figure B-3. Harris School Skill Mean Scores

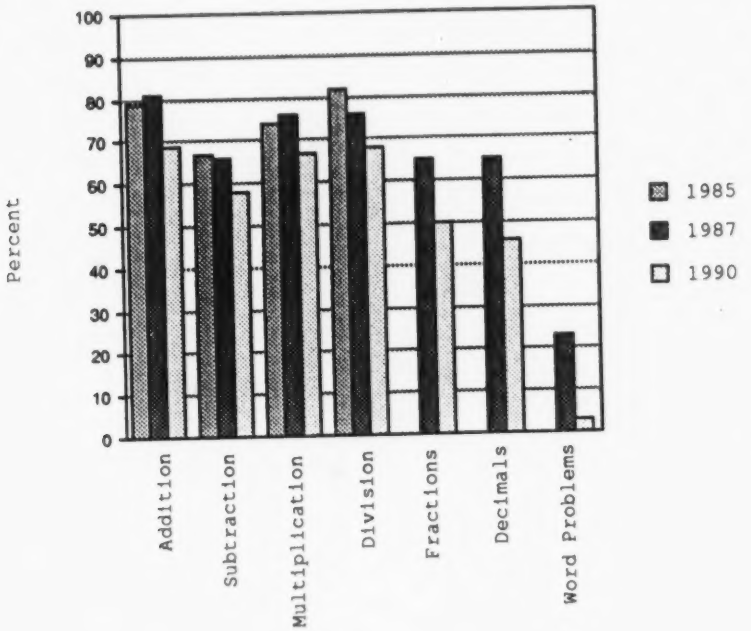

Figure B-4. Harris School Grade Level Mean Scores

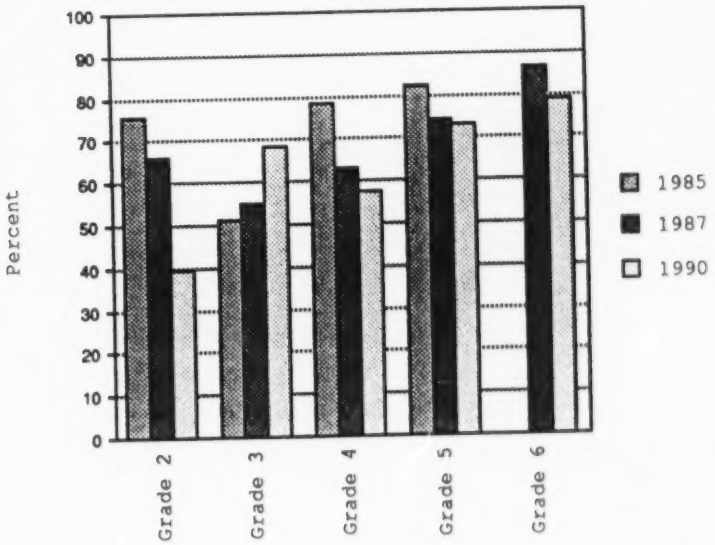

Figure B-5. Meyuns School Skills Mean Scores

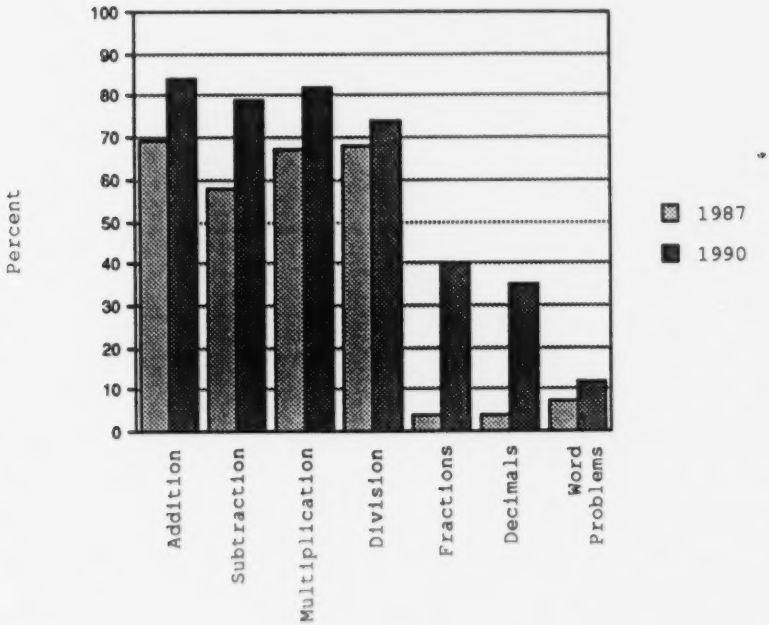

Figure B-6. Meyuns School Grade Level Mean Scores

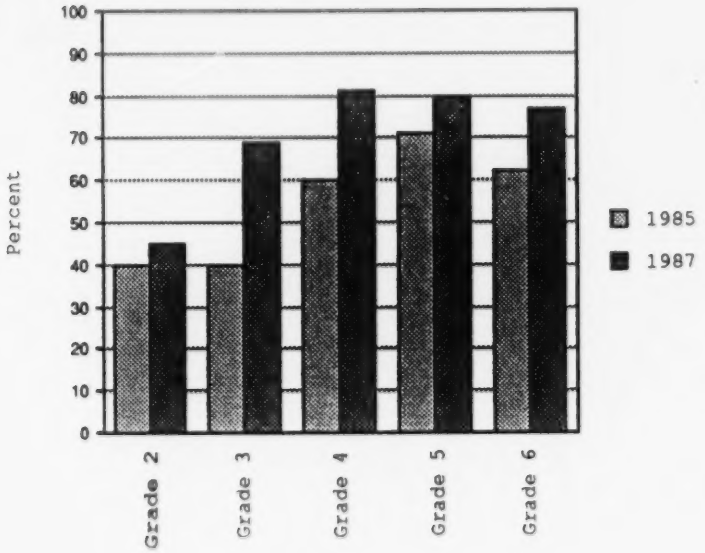

Figure B-7. Comparison of Grade Level Means for 1987

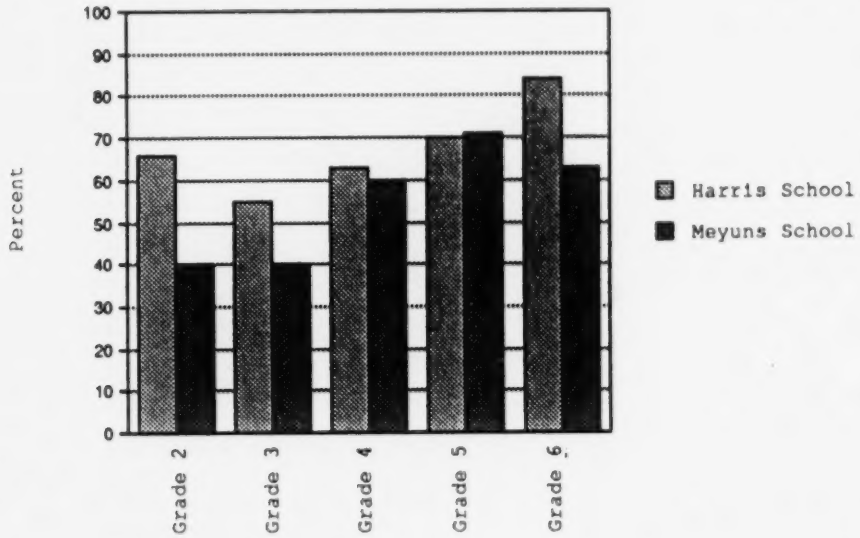

Figure B-8. Grade level means for 1990